THE EFFECTS OF SOIL FAUNA ON THE DECOMPOSITION OF *EUCALYPTUS* LEAF LITTER IN THE SNOWY MOUNTAINS, AUSTRALIA

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INTRODUCTION

In spite of the dominance of *Eucalyptus* forests in Australia there is little information on nutrient cycling in these communities. The rates of litter fall and its decomposition are important aspects of nutrient cycles and are also of significance in soil formation and aspects of fire protection such as controlled burning operations.

Several workers (ASHTON, 1956 ; FLORENCE, 1961 ; HANNON, 1958 ; JACOBS, 1963 ; STOATE, 1958 ; TURNER, 1954 ; WEBB — in BRAY and GORHAM, 1964) have published information on the rate of litter fall in Australian *Eucalyptus* forests and HATCH (1955), MCCOLL (1966) and ATTIWILL (1968) have investigated the rate of litter fall and its decomposition. These latter investigations were, in each case, concerned with the decomposition of the litter of one species so that it is not possible to say whether or not differences in the rate of decomposition between species are due to the nature of the litter or the nature of the site. Furthermore, none of these investigations considered the role of organisms in the breakdown of *Eucalyptus* litter.

The studies reported here are concerned with the decomposition of leaves of two species of *Eucalyptus* during a period of 18 months and are part of a more extensive investigation of the soils and soil fauna of montane, sub-alpine and alpine habitats on Mt. Kosciusko.

SITES

Three sites were studied on the eastern side of Mt. Kosciusko, New South Wales. COSTIN (1954) has described botanical, pedological and climatological features of the region. Soil temperatures and soil moistures during the first 12 months of decomposition are shown in table 1.

TABLE I

Soil moisture contents (p. 100 dry weight) *and temperatures* (°C) *at 3-monthly intervals during the first 12 months of litter decomposition*

Date	Depth (cm)	Dry sclerophyll		Wet sclerophyll		Alpine herbfield	
		Moisture	Temperature	Moisture	Temperature	Moisture	Temperature
Feb. 1968	0-4	7.9	16.0	16.0	13.5	31.8	11.5
	12-16	5.7	14.0	17.8	13.0	37.6	10.0
May 1968	0-4	22.5	6.5	40.6	3.0	58.0	1.0
	12-16	11.5	10.0	25.0	8.5	48.2	3.0
Aug. 1968	0-4	15.0	4.5	31.8	0.5	50.0	0.5
	12-16	37.2	4.0	39.2	1.0	42.2	1.0
Nov. 1968	0-4	28.0	11.0	33.3	11.0	48.0	8.0
	12-16	12.5	9.0	23.8	7.0	46.1	5.5
Feb. 1969	0-4	17.5	19.0	22.8	14.5	38.0	13.0
	12-16	11.2	14.0	19.3	12.5	43.1	10.5

Dry sclerophyll forest

The vegetation is a *E. pauciflora* SIEB. ex SPRENG.-*E. dalrympleana* MAIDEN association (COSTIN, 1954) and is at the wet end of the dry sclerophyll forest formation and lies within the *E. delegatensis* R. T. BAKER-*E. dalrympleana* wet sclerophyll forest alliance. It is located at an elevation of 4 230ft (1 290 m) on a moderate (12-15°) north-east facing slope. Although the soil has been called an iron podzol (COSTIN, 1954) it is more accurately classified as a podzolic soil or in terms of NORTHCOTE'S (1965) classification as a Dr 4.21 soil. The annual rainfall is about 35 in (889 mm) and there is only moderate, non-persistant, winter snow. Mean air temperature is 8.2°C.

Wet sclerophyll forest

The vegetation is a *E. delegatensis* association (COSTIN, 1954). It is located at an elevation of 5 000 ft (1 520 m) on a steep (25°) south-facing slope. The soil is a transitional alpine humus soil (COSTIN, *loc. cit.*) and in NORTHCOTE'S (1965) terminology is classified as a Um 7.11 soil. The annual rainfall is about 45 in (1 144 mm) and there is moderate winter snow which, due to the aspect of the site, may persist for more than a month. Mean air temperature is 6.8°C.

Alpine herbfield

The vegetation is a *Poa caespitosa-Celmisia longifolia* CASS. association (COSTIN, 1954). It is located at an elevation of 6 400 ft (1 950 m) in the treeless alpine zone on a moderate (8-10°) north-east facing slope. The soil is an alpine humus soil and in NORTHCOTE'S (1965) terminology is classified as a Um 1.44 soil. The annual precipitation is about 85 in (2 160 mm) and there is heavy winter snow which may persist for up to 5 months. Mean air temperature is 3.3°C.

MATERIALS AND METHODS

Animal populations

Soil animal populations were studied at these sites at intervals of three months over a period of two years. On each occasion the following samples were taken at each site for different groups of organisms.

1. Earthworms and macrofauna — 10 samples 1/16 sq. m in area by 0.5-1.0 m deep, extracted by hand-sorting.

2. Enchytraeidae — 10 samples 20 sq. cm in area by 16.0 cm deep, extracted in layers 4 cm thick in heated Baermann funnels (O'CONNOR, 1962).

3. Micro-arthropods — 8 samples 20 sq. cm in area by 16.0 cm deep, extracted in layers 4 cm thick in air conditioned « funnel » extractors.

4. Nematodes — 10 samples 4.5 sq. cm in area by 16.0 cm deep, extracted in Baermann funnels.

Litter decomposition

The materials used were leaves of *E. pauciflora*, one of the dominant trees at the dry sclerophyll site, and *E. delegatensis*, the dominant tree at the wet sclerophyll site. Leaf litter was obtained by cutting large branches from single trees of *E. pauciflora* and *E. delegatensis*. The branches were kept under shelter (to avoid leaching by rain) for three months after which time the leaves, which were brown, were picked and allowed to come to a constant moisture content in a laboratory.

Small samples of litter were used to estimate moisture content and then weighed samples were placed in terylene mesh bags, the open ends of which were sealed with rot-resistant tape. Approximately 7 g dry weight equivalent of leaves per bag was used in these experiments. The bags measured 20 cm × 16 cm and 7 g of *Eucalyptus* leaves in this area (320 sq. cm) is approximately equivalent to the probable annual leaf-fall of 2 000-2 500 kg/ha. The bags used in the present experiments were of three types having meshes which gave holes of the following sizes :

small mesh .... 0.03 mm diameter
medium mesh .. 0.50 mm diameter
large mesh .... 10.0 × 7.0 mm

The small mesh gives access only to micro-flora and microfauna (nematodes, tardigrades etc., although a few minute mites, principally *Tarsonemidae* and *Tydeidae*, and some *Enchytraeidae* have been found inside these bags). The medium mesh gives access to the above groups and also to the mesofauna (mites, *Collembola*, *Protura*, small *Diptera* larvae, *Enchytraeidae* etc.) and the large mesh gives access to the above groups and also to the macrofauna (larger insects, myriapods, earthworms etc.).

The bags were laid on the forest floor in the two sclerophyll forest sites after removal of freshly fallen leaf litter and were held on the ground with strands of nylon fishing line pegged at each side of the bag in order to prevent them being removed by currawongs (*Strepera graculina* SHAW) and magpies (*Gmnorhina hypoleuca* G.). In the alpine site the grass was short (3 in ; 7.6 cm) and it would have been impossible to prevent magpies or ravens (*Corvus coronoides* V. H.) from removing or damaging bags placed on the surface. Consequently the bags were placed in slits cut under the surface of the soil.

The bags were located at each site in February, 1968. At intervals of three months three randomly selected bags of each bag/litter type were removed from the field, macrofauna removed by hand and smaller animals by extraction in modified Tullgren funnels. The samples were then dried at 35°C and weighed. Deep snow prevented the first samples of decomposing litter being removed from the alpine site until after a period of 9 months.

RESULTS

Animal populations

Detailed analyses of the populations of soil animals are not relevant here and will be published elsewhere. The mean numbers and biomasses of macrofauna, mesofauna and microfauna are shown in table 2 where the first two of these groups have been divided into predators and herbivores/saprophages (henceforth referred to as « decomposers »).

TABLE 2

Population density (numbers/m²) *and biomass* (g/m²) *of soil animals in three sites on Mt. Kosciusko*

(Figures are means of 4 estimates made at 3-monthly intervals)

Fauna	Dry sclerophyll forest		Wet sclerophyll forest		Alpine herbfield	
	Numbers	Biomass	Numbers	Biomass	Numbers	Biomass
Macrofauna :						
Megascolecidae	49.0	16.68	105.5	40.70	88.3	41.23
Arthropoda						
— herbivores and decomposers	83.8	7.22	180.0	10.03	126.0	15.27
— predators	686.5	2.95	384.9	2.48	7.6	1.05
Mesofauna :						
Enchytraeidae	250	< 0.01	1,075	0.38	3,250	2.07
Arthropoda						
— herbivores and decomposers	69,450	0.29	129,150	1.07	117,500	0.41
— predators	9,200	0.10	20,500	0.25	5,500	0.06
Microfauna :						
Nematoda	7,449,650	1.63	5,939,500	2.05	2,562,250	0.75
Total biomass		28.98		57.00		60.84

The dry sclerophyll forest is characterized by low earthworm populations, low populations of large decomposers but high populations of large predators, low populations of *Enchytraeidae*, low populations of small decomposers and small predators and high populations of nematodes. The numbers of all groups, with the exception of ants which comprise most of the numbers and approximately half of the biomass of large predators, are very much depressed in summer. Cicada nymphs and various larvae of *Coleoptera* and *Diptera* are the dominant groups in the large decomposer category.

The wet sclerophyll forest is characterized by high earthworm populations, high populations of large decomposers and large predators, relatively high populations of *Enchytraeidae*, high populations of small decomposers and small predators and relatively high populations of nematodes. Ants comprise most of the numbers of

large predators but the biomass of this category is dominated by *Chilopoda* and *Japygidae* (*Heterojapyx evansi* WOMERSLEY). Cicada nymphs, various *Coleoptera* (particularly *Scarabaeidae*) and *Diptera* larvae, *Diplopoda* and *Isopoda* are the dominant groups in the large decomposer category. *Lepidoptera* larvae (particularly *Tortricidae*) are also a significant group, many of which, particularly early instars, fall into the small decomposer category. Although numbers of all groups, except ants, are depressed in summer, the decrease is less than in the dry sclerophyll forest.

The alpine herbfield is characterized by high earthworm populations, high populations of large decomposers but very low populations of large predators, relatively high populations of Enchytraeidae, high populations of small decomposers but low populations of small predators and low populations of nematodes. Populations are slightly lowered in summer but not as much as in the two forest sites and high populations are maintained during winter under a permanent cover of snow. *Chilopoda* and *Aranei* are the dominant large predators and the large decomposer category is dominated by *Megascolecidae* and *Scarabaeidae*. Diptera larvae, particularly *Chironomidae*, are more abundant in the small decomposer category in this site than in the two sclerophyll forest sites.

Noteworthy features of these populations are the large number of earthworms in the alpine herbfield site (soil pH 4.3-4.9), the ratios of numbers and biomass of decomposers to predators which increase from dry sclerophyll to alpine herbfield and the low populations of *Enchytraeidae* relative to many sites in Europe.

Litter decomposition

Comparison of the weight losses in small, medium and large mesh bags enables one to assess the contribution which the different groups of organisms make towards decomposition, providing the following assumptions are made. Firstly, that the type of bag has no effect on the rate of leaching of soluble components by rainwater and secondly, that microbial activity is the same in the three different types of bag and that mesofaunal activity is the same in medium and large mesh bags. These assumptions have not been tested, either in the present work or by others (eg. EDWARDS and HEATH, 1963) who have used these methods.

The results showed that for both types of litter in all sites the loss in weight was greatest in the large mesh bags and least in the small mesh bags, indicating that exclusion of the mesofauna and macrofauna retarded decomposition. If one assumes that the loss of weight in the large mesh bags represented « natural » decomposition, the contribution of different groups of organisms to this loss in weight can be calculated. If a_1, a_2, b_1, b_2, c_1, c_2, are the p. 100 dry weights of litter remaining in the large, medium and small mesh bags respectively at times t_1 and t_2, the percentage weight lost due to

1. Leaching + microflora + microfauna $= (c_1 - c_2) \cdot \dfrac{a_1 + a_2}{c_1 + c_2} = C$

2. Mesofauna $= \left[(b_1 - b_2) \cdot \dfrac{a_1 + a_2}{b_1 + b_2}\right] - C = B$

3. Macrofauna $= (a_1 - a_2) - (C + B)$.

These losses, calculated for each sampling occasion are shown in figure 1 and the total loss due to these groups of organisms during 18 months is shown in table 3.

With the exception of *E. delegatensis* litter in the wet sclerophyll and alpine herbfield sites leaching and micro-organisms were responsible for 70 p. 100 or more of the total loss in weight (table 3). The mesofauna contributed as much as the macro-

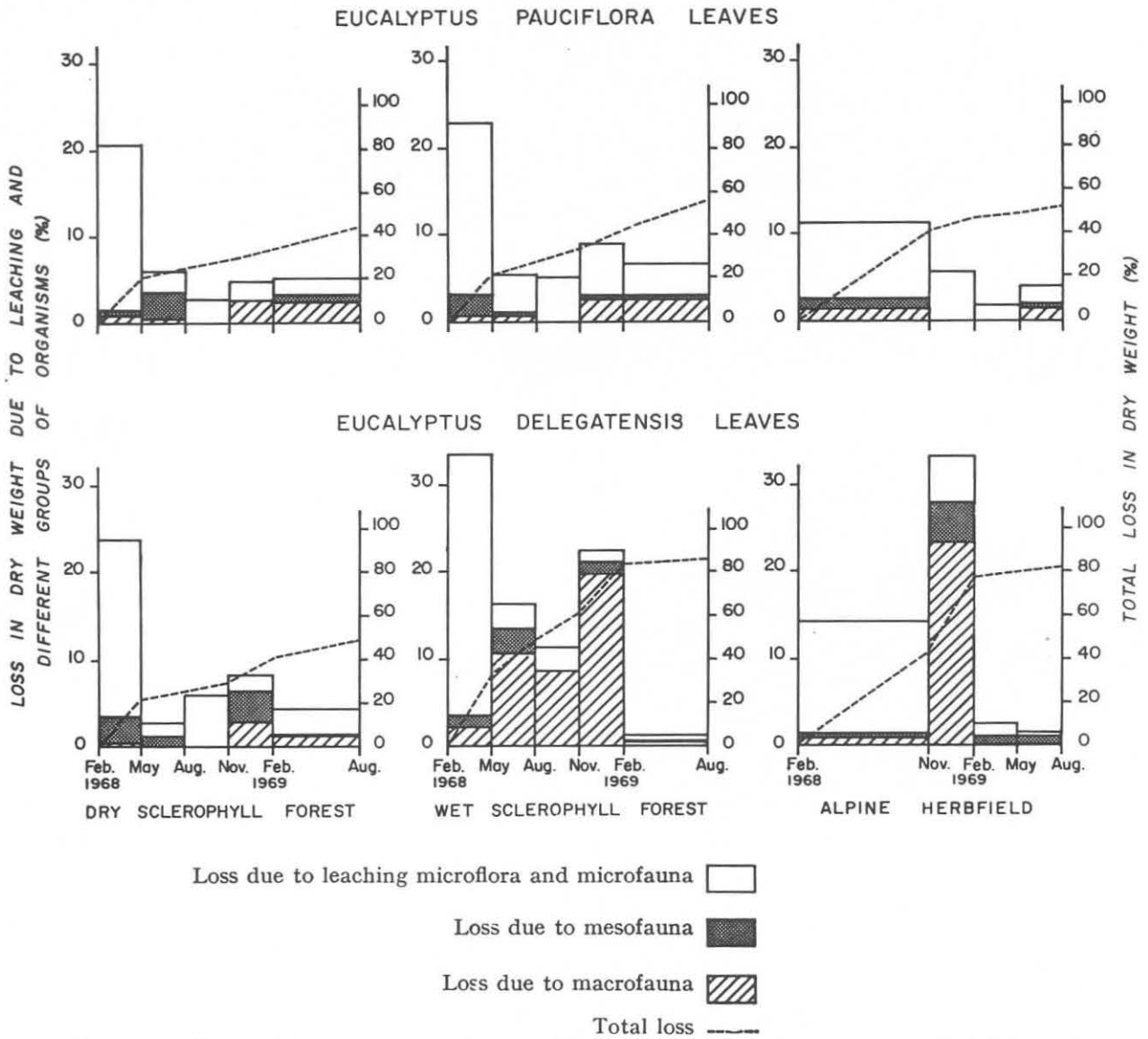


FIG. 1. — *Seasonal progress in the decomposition of* Eucalyptus pauciflora *and* E. delegatensis *leaves in three sites on Mt. Kosciusko; total decomposition and decomposition due to different groups of organisms*

fauna to the total loss in weight with the exception of *E. delegatensis* litter in wet sclerophyll and alpine herbfield, where the macrofauna contributed 7.6 and 3.7 times more respectively than the mesofauna towards decomposition. The losses from both *E. pauciflora* and *E. delegatensis* due to the mesofauna and from *E. pauciflora* due to the macrofauna were similar in all sites in spite of the differences in populations and biomasses. However, there were significant differences between the losses from *E. delegatensis* due to the macrofauna, the greatest loss being in wet sclerophyll and the least in dry sclerophyll. *E. delegatensis* decomposed more rapidly than *E. pauciflora* in all sites and both litters decomposed more rapidly in wet sclerophyll and alpine herbfield than in dry sclerophyll.

The seasonal changes in decomposition shown in figure 1 clarify the significance of leaching and different groups of organisms. In the two sclerophyll forest sites the rapid initial loss in weight from all the litters during the first 3 months was almost certainly due to leaching of readily soluble components from the litter. This effect

TABLE 3

Decomposition of Eucalyptus *leaves by different groups of organisms during 18 months*

(sum of p. 100 loss in dry weight at 3-monthly intervals — see text)

	Dry sclerophyll forest		Wet sclerophyll forest		Alpine herbfield	
	P	D	P	D	P	D
Leaching + microflora ..... + microfauna	30.4	35.9	42.9	40.4	44.2	50.5
Mesofauna	5.7	8.0	3.5	5.4	3.0	6.9
Macrofauna	8.2	5.7	9.8	41.1	6.7	25.4
Total	44.3	49.6	56.2	86.9	53.9	82.8

P = *E. pauciflora* D = *E. delegelatensis.*

was greater in the wet sclerophyll site which has a greater rainfall than the dry sclerophyll site. Thereafter loss due to leaching and activity of micro-organisms levelled off at a more or less constant rate. The losses due to mesofauna did not appear to follow any obvious pattern although the greatest loss occurred during the first 6 months. With the exception of *E. delegatensis* in wet sclerophyll there was very little attack by macrofauna during the first 9 months. In the wet sclerophyll intense attack on *E. delegatensis* by earthworms, which removed whole pieces of leaf tissue, and larvae of *Tortricidae* other *Lepidoptera* and various *Diptera*, which « skeletonized » the leaves, was apparent after 3 months. This attack continued throughout the winter and intensified during the November to February period with the result that after 12 months the leaves had lost 84.3 p. 100 of their original weight and the remaining tissue was largely mid-ribs and veins. *E. pauciflora* appeared to be less palatable to the macrofauna as earthworms did not appear to consume it and macrofaunal attack after 9 months was largely due to larvae of *Tortricidae* and various *Diptera*. The seasonal pattern of decomposition was less clear for the alpine herbfield site as 9 months elapsed before the first samples were retrieved. It is likely that most of the loss due to leaching and micro-organisms occurred during the first 3 months. After 9 months, that is during the November-February period there was an intense attack (33.5 p. 100 total loss in weight) on *E. delegatensis* litter, principally by macrofauna (largely earthworms) and to a lesser extent by mesofauna (largely *Enchytraeidae* and *Chironomidae* larvae) with the result that 78.4 p. 100 of the litter had disappeared after

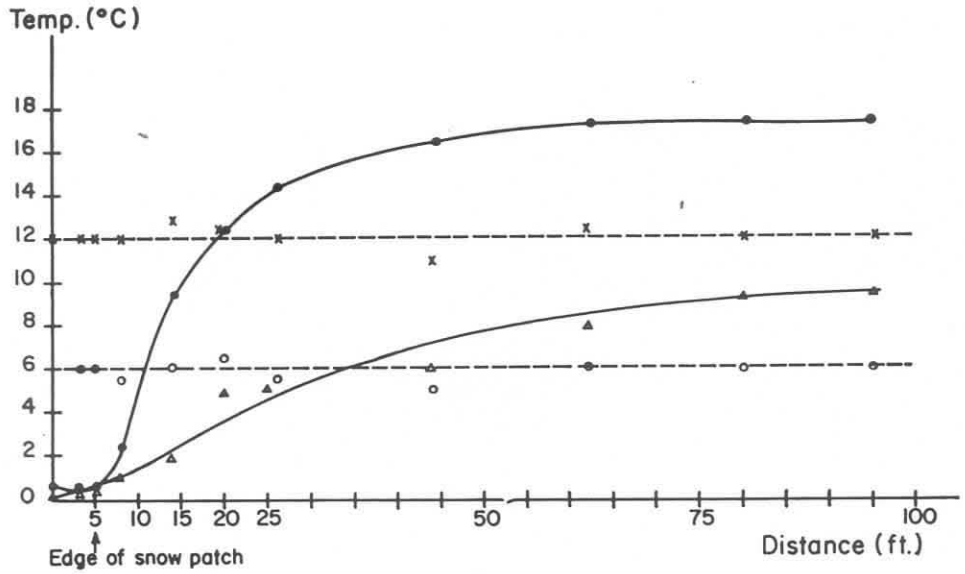
12 months. In contrast there was little attack on *E. pauciflora* by the macrofauna. Earthworms did not appear to attack this species and the small amount of decomposition by macrofauna appeared to be carried out mainly by *Diptera* larvae.

DISCUSSION

In general *Eucalyptus* leaves appear to decompose more slowly than leaves of many European broad-leaved trees. Annual weight losses through decomposition of various species of *Eucalyptus* are : *E. obliqua* (green leaves), 48.6 p. 100 (ATTIWILL, 1968) ; *E. marginata*, 37.7 p. 100 (HATCH, 1955) ; *E. maculata*, 36.0 p. 100 (MCCOLL, 1966) ; *E. pauciflora* (in dry sclerophyll forest) 34.2 p. 100 and *E. delegatensis* (in wet sclerophyll forest) 84.3 p. 100. In contrast all but one of the species studied by HEATH, ARNOLD and EDWARDS (1966) in southern England had lost more than 90 p. 100 of their original weight after 12 months and the exception (beech, *Fagus sylvatica* L.) had lost this amount after 15 months. Similarly rapid rates of decomposition were obtained by BOCOCK *et al.* (1960) in northern England and WITKAMP and VAN DER DRIFT (1961) in Holland. In Europe lumbricid earthworms are one of the major factors responsible for the rapid removal of many types of leaf litter (see references quoted above ; also RAW, 1962) by dragging leaves down into their burrows as well as ingesting them *in situ* at the surface. Megascolecid earthworms in the sites studied on Mt. Kosciusko only ingest leaf litter *in situ* but it is not known whether or not other megascolecids drag leaves into their burrows. However, this does not explain the slow rate of decomposition of four of the five species of *Eucalyptus* leaf mentioned above as one species, *E. delegatensis* decomposes rapidly. The answer may lie partly in the palatability of *Eucalyptus* leaves to soil organisms (about which there is no precise information) and partly in the nature of the soil fauna. For instance the marked difference in the rate of decomposition between *E. pauciflora* and *E. delegatensis* in wet sclerophyll forest and alpine herbfield is largely due to differences between the amounts consumed by the macrofauna (earthworms and *Diptera* larvae in the alpine herbfield and earthworms, *Diptera* larvae and tortricid larvae in the wet sclerophyll forest). In the dry sclerophyll forest there is less difference between the two species and the slow rate of decomposition of *E. delegatensis* in this site is probably due to the low density of « decomposer » macrofauna and the fact that the activity of these animals (particularly the earthworms) is low in summer.

Although a general relationship between the rate of decomposition of litter and air temperature has been reported (JENNY, GESSEL and BINGHAM, 1949 ; KIRA and SHIDEI, 1967 ; MIKOLA, 1960) it does not appear to hold for the three sites studied on Mt. Kosciusko, either for the two species of *Eucalyptus* leaf or for leaves and roots of the snowgrass, *Poa caespitosa* (WOOD, 1970). Nor does this relationship hold when mean soil temperatures are considered (table 1) and the relatively rapid decomposition of litter in the alpine site is most probably related to intensive seasonal biological activity. The alpine humus soils, in which temperatures lie between 0°C and 2°C for up to 5-6 months of the year, are subjected to a short period in spring when the soils are wet from melting snow but also warm. Soil temperatures under a melting snow drift and in snow-free areas at increasing distances beyond the drift are shown

in figure 2. The transition from soil temperatures of 0.5°C under snow to temperatures approaching 18°C in areas affected by water from the snow drift takes place very rapidly. In fact if the sun is shining the warm water flowing over the surface



2 cm depth 19 nov. Air temp. 13°C
15 cm depth 19 nov. Air temp. 13°C
2 cm depth 30 nov. Air temp. 14°C
15 cm depth 30 nov. Air temp. 14°C

FIG. 2 — *Soil temperatures under melting snow drift and in snow-free areas beyond the drift at the alpine herbfield site and temperatures at the same positions 11 days later when the snow had disappeared*

and draining through the soil warms the soil to temperatures exceeding air temperature. Soil temperatures at the same positions eleven days later, when the snow had disappeared, had stabilized at a slightly lower level around 12°C and remained around this level for 3-4 months. During this period of warmth and ample soil moisture there was a very rapid decomposition of *E. delegatensis* (fig. 1) probably due to increased activity by earthworms.

RÉSUMÉ

ACTION DE LA FAUNE DU SOL
DANS LA DÉCOMPOSITION DE LA LITIÈRE DE FEUILLE D'EUCALYPTUS
DANS LES MONTAGNES ENNEIGÉES D'AUSTRALIE

Les feuilles d'*Eucalyptus delegatensis* se décomposent plus rapidement que celles d'*Eucalyptus pauciflora* dans la forêt sclérophylle sèche (1 290 mètres, sol podzolique), dans la forêt sclérophylle humide (1 520 mètres, sol humique alpin de transition) et dans l'herbage alpin (1 950 mètres, sol humique alpin). Après 18 mois, l'action du lessivage et des microorganismes était responsable de 70 p. 100, ou davantage, de la perte de poids total des deux sortes de feuilles dans tous les sites, à l'exception des feuilles d'*Eucalyptus delegatensis* dans le site sclérophylle humide et dans le site alpin où la décomposition rapide (87 p. 100 et 83 p. 100 de perte de poids totale, respectivement) était, dans une large mesure, due à l'attaque intense de la macrofaune. La décomposition des feuilles d'*Eucalyptus delegatensis*, dans la forêt sclérophylle humide, est

réalisée en grande partie par les vers de terre (*Megascolecidae*), les larves de *Tortricidae* et par divers Diptères qui sont actifs pendant tout l'hiver, tandis que dans l'herbage alpin, la décomposition des feuilles est, en grande partie, réalisée par les vers de terre au printemps et au début de l'été, quand les sols sont chauds et humides.

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DISCUSSION

M. MALDAGUE : Votre conclusion sur le rôle de la macrofaune dans la décomposition des litières d'*Eucalyptus* correspond aux observations que nous avons faites dans une érablière à sucre du Canada. Avez-vous calculé l'accumulation de la matière organique dans le sol et pouvez-vous la mettre en relation avec la vitesse de disparition des feuilles ?

T. G. Wood : No, I have not measured litter-fall at these sites although there are approximate figures available from other sources. It appears that litter falls more quickly than it decomposes at these sites and in other *Eucalyptus* forests that have been studied in Australia. In some forests bark is a dominant constituent of the litter ; it decomposes very slowly (less than 15 p. 100 loss in weight in these sites in 18 months) and constitutes a distinct fire-hazard.

P. Berthet : From your experiment, we observe that the *Eucalyptus* leaves disappear nearly at the same rate in the wet sclerophyll forest, where there are many *Eucalyptus* trees, as in the alpine site where *Eucalyptus* in completely absent. Would it mean that the fauna is not specialized at all or that there are some compensatory mechanisms that maintain the disappearance rate at the same level ?

T. G. Wood : The results suggest that the fauna is not specialized as the species present in the wet sclerophyll forest are different to the species in the alpine herbfield.

C. A. Edwards : I should like to comment on Dr Berthet's question concerning introducing leaves into an alien environment. Some years ago we buried oak and leaf litter in pasture soil as well as in woodland and found little difference in amount of breakdown. Our data supports that of Dr Wood.

M. S. Ghilarov : 1° What Megascolecid worms were in your experiments according to Lee's ecological classification (which coincides with classification of Lumbricidae ecological groups proposed by Baluev, and later by Wilcke) ?

2° You have found that small animals are of little importance. But probably it is due to the changes of hydric regime in bags of net with very fine meshes, which isolate litter sample from small Arthropods.

3° The data by Dr Wood that Megadrili worms are especially efficient litter destroyers are in good concordance with those obtained in England (Edwards, Satchell) and with those by T. S. Perel in U. S. S. R.

T. G. Wood : 1° There are species which are largely confined to the surface litter or live near the surface ; other species are inhabitants of deeper layers but move between surface and sub-surface regions ; there are none of the extremely large species which are usually confined to the sub-soil.

2° The effect of the nylon bags on the micro-environment around leaves is unknown and I know of no measurements of moisture or humidity within bags by other workers who have used these methods.

3° Although the *Megascolecidae* consume *Eucalyptus* leaves they do not drag whole leaves down into their burrows (as does *Lumbricus terrestris*) and do not appear to feed on freshly-fallen leaves.

J. M. Anderson : I should like to comment on the validity of the litter bag method for the investigation of litter breakdown and decomposition. I have found no statistically significant differences between the rates of litter *decomposition* in 1 mm and 48 μ mesh bags ; and also no significant differences in the water retentive capacities of the two types of bag.

I notice that Dr Wood's slides show the cracking of *Eucalyptus* leaves with drying. I have found that in a *Castanea* moder that this behaviour of the leaves may be a more important process in litter breakdown than the feeding activities of soil animals. Has Dr Wood made any similar observations ?

T. G. Wood : The cracking of leaves shown in the slides is an artefact caused by flattening them for photographic purposes.

N. Haarlov : From the papers of professor Birch terrestrial Amphipoda are considered an important decomposer group in *Eucalyptus* forests.

Are they found in the habitats you investigated ?

T. G. Wood : There are a few Amphipoda in the wet sclerophyll forest, but none in the other two sites. Amphipoda are abundant in sub-alpine woodland which occurs at altitude between wet sclerophyll forest and alpine herbfield.

J. Van Der Drift : Explanation for formulae on the food of page 305.

T. G. Wood : Consider for simplicity the weight lost in the small and large mesh bags only. The weight lost from leaves in the small mesh bags during the period t_1 to t_2 is given by $c_1 - c_2$, but the loss in weight due to leaching + microflora + microfauna must be calculated on the basis of the weight of leaves in the large mesh bags which, due to more rapid decomposition is always less than that in the small mesh bags. The mean weight of material in the small and large mesh bags during the period t_1 to t_2 is $\frac{c_1 + c_2}{2}$ and $\frac{a_1 + a_2}{2}$ respectively. Thus the loss in weight $c_1 - c_2$, in the small mesh bags must be corrected, by a factor $a_1 + {}_2 \bar{i} c_1 + c_5$.

G. Marcuzzi : I have the impression that decomposers of *Eucalyptus* are more specific than decomposers of European trees. In Italy there are several *Eucalyptus* stand and in general there

are no animals able to attack *Eucalyptus* leaves (and wood). I would like to know Dr Wood's opinion about that.

T. G. Wood : There is a large and diverse fauna of Lepidoptera, particularly Tortricidae and related families, in *Eucalyptus* forests and many of these live in the litter and together with certain Diptera larvae are important in attacking freshly-fallen *Eucalyptus* leaves. It is likely that this specialized fauna is not present in Italy. In Australia decomposition of woody litter is slow and this is particularly noticeable in forests dominated by species that shed large quantities of bark. Bark of *Eucalyptus dalrympleana* exposed in the dry and wet sclerophyll forests lost less than 10 p. 100 dry weight after 18 months.